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EVALUATION OF DOD WASTE SITE GROUNDWATER
PUMP-AND-TREAT OPERATIONS

Report Number 98-090

March 12, 1998

Office of the Inspector General
Department of Defense

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Acronyms

BRAC	Base Realignment and Closure Act
DERA	Defense Environmental Restoration Account
DERP	Defense Environmental Restoration Program
DNAPL	Dense Non-Aqueous Phase Liquid
EPA	Environmental Protection Agency
NPL	National Priority List



INSPECTOR GENERAL
DEPARTMENT OF DEFENSE
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March 12, 1998

MEMORANDUM FOR DEPUTY UNDER SECRETARY OF DEFENSE
(ENVIRONMENTAL SECURITY)
ASSISTANT SECRETARY OF THE ARMY
(INSTALLATIONS, LOGISTICS, AND
ENVIRONMENT)
ASSISTANT SECRETARY OF THE NAVY
(INSTALLATIONS AND ENVIRONMENT)
ASSISTANT SECRETARY OF THE AIR FORCE
(MANPOWER, RESERVE AFFAIRS, INSTALLATIONS
AND ENVIRONMENT)
DIRECTOR, DEFENSE LOGISTICS AGENCY
AUDITOR GENERAL, DEPARTMENT OF THE ARMY

SUBJECT: Evaluation Report on DoD Waste Site Groundwater Pump-and-Treat
Operations (Report No. 98-090)

We are providing this report for review and comment. We considered management comments on a draft of this report in preparing the final report. Since those comments were responsive, no further responses are necessary.

We appreciate the courtesies extended to the evaluation staff. Questions on the evaluation should be directed to Mr. William C. Gallagher, Evaluation Program Director, at (703) 604-9270 (DSN 664-9270) or Mr. Michael R. Herbaugh, Evaluation Project Manager, at (703) 604-9294 (DSN 664-9294). See Appendix F for the report distribution. The evaluation team members are listed inside the back cover.



Robert J. Lieberman
Assistant Inspector General
for Auditing

Office of the Inspector General, DoD

Report No. 98-090
(Project No. 6CB-0057)

March 12, 1998

Evaluation of DoD Waste Site Groundwater Pump-and-Treat Operations

Executive Summary

Introduction. In FY 1996, the DoD operated 75 pump-and-treat systems as a primary remedy at sites where the groundwater is contaminated by chlorinated solvents. This evaluation report discusses the financial and technical aspects of the operation and maintenance of current pump-and-treat systems.

Evaluation Objectives. The objective was to determine the cost and effectiveness of DoD groundwater pump-and-treat remediation efforts. Specifically, we focused on groundwater contaminated with chlorinated solvents.

Evaluation Results. Pump-and-treat systems remediate contamination slowly, cost \$40 million annually as of FY 1996, and will not allow DoD to meet required cleanup goals within a reasonable time. Many pump-and-treat systems were designed before more innovative technologies were available.

If DoD continues the operation of many pump-and-treat systems with indefinite shut-off dates, increasing proportions of the Defense Environmental Restoration Account will be required to fund the continuing operations and monitoring of the costly systems for the foreseeable future. Alternative cleanup methods may be feasible and more appropriate for many sites.

Summary Of Recommendations. We recommend that the Deputy Under Secretary of Defense (Environmental Security), the Army, the Navy, the Air Force and the Defense Logistics Agency reevaluate existing pump-and-treat systems to determine if costs can be reduced, performance improved, or systems replaced with alternative technology. We also recommend that a systematic approach be developed in cooperation with environmental regulators, the scientific community, and the public to determine more effective alternative methods for future groundwater clean up.

Management Comments. We received comments from the Deputy Under Secretary of Defense (Environmental Security); Department of the Army, Assistant Chief of Staff for Installation Management; Department of the Army, Corps of Engineers; Department of the Navy; Department of the Air Force; and the Defense Logistics Agency. The Deputy Under Secretary of Defense (Environmental Security), the Defense Logistics Agency, Department of the Army, Department of the Navy, and the Department of the Air Force generally or partially concurred with the finding and recommendations. They are already in process of or planning to implement the recommendations, to which they offered minor suggested changes. Management comments indicate that, whenever feasible, natural attenuation is the preferred

comments indicate that, whenever feasible, natural attenuation is the preferred technology for remediation of recent and all future cleanup actions. Management also stated that Federal regulations require the review of remedial cleanup decisions every 5 years; however, DoD has not published policy requiring that review. See Part I for a discussion of management comments, and Part III for the complete text of those comments.

Evaluation Response. Management comments were responsive. Many of those comments were incorporated throughout the final report; however, some comments were outside the scope of this project and consequently were not discussed in the report. Also, we revised Recommendation 1. as suggested. We welcome the Department's assurances that actions are under way to pursue alternatives to pump-and-treat technology. No further comments are required.

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Part I - Evaluation Results

Evaluation Background

Discussion. In 1984, Congress established the Defense Environmental Restoration Program (DERP). This program earmarked special funds to study and cleanup contaminants at DoD waste sites. The 1996 DERP Annual Report to Congress states that DoD invested almost \$15 billion in its environmental restoration program through FY 1996. Of that \$15 billion, approximately \$11.4 billion was invested in the Defense Environmental Restoration Account (DERA); and approximately \$3.5 billion went to the Base Realignment and Closure Act (BRAC) account. See Appendix E for definitions of environmental cleanup terms.

Financial Concerns. The FY 1998 National Defense Authorization Act indicates congressional concern about the growing costs associated with environmental cleanup at active and former military installations. In an earlier report in the Congressional Budget Office Papers, (January 1995) that same concern was raised:

To date, the Congress has been able to authorize sufficient funding to meet DoD's requirements. Given the increasing costs of remediation, however, DoD may not be able to meet the requirements of its cleanup program on schedule and within budgetary projections. The Department of Defense and the Congress could consider alternative approaches to the cleanup program to ensure that the department's most important cleanup requirements are met within increasingly constrained budgetary allowances.

DoD Instruction 4715.7, "Environmental Restoration Program". This instruction, released April 22, 1996, provides guidelines, implements and refines policies, assigns responsibilities, and prescribes procedures for the DERP and the BRAC environmental restoration program. This DoD instruction applies to all DoD components and to Defense agencies with land management responsibilities. In general, the goal of the DERP and BRAC Environmental Restoration Program is to reduce, in a cost-effective manner, the risks to human health and the environment as a result of contamination because of past DoD activities. Specifically this goal is accomplished through policy developed by Deputy Under Secretary for Defense (Environmental Security) through the Under Secretary of Defense for Acquisition and Technology.

With respect to DoD groundwater cleanup and the use of pump-and-treat systems as a method of remediation, the Military Departments do not have a formal policy. Although the National Oil and Hazardous Substance Pollution Contingency Plan requires a review every 5 years of final cleanup remedies, there is no DoD requirement to revisit active pump-and-treat systems at DoD sites. At the time of data collection for this report, those systems continued to operate without any form of review to determine their efficiency and effectiveness. See Appendix D for environmental laws and regulations applicable to DoD environmental remediation.

DoD Pump-and-Treat Systems. Pump-and-treat systems are one of the most widely used groundwater cleanup technologies. Conventional pump-and-treat systems involve pumping contaminated groundwater to the surface for treatment. The systems came into wide use in the mid-1980s; however, by the early 1990s, regulators, scientists, DoD, and the Military Departments began questioning the effectiveness of pump-and-treat systems.

Groundwater pump-and-treat systems can be used to contain a plume (thus preventing spread of contamination), or to clean up groundwater. Several options or groups of options are available to remediate contaminated groundwater:

- o provide in-ground treatment/containment,
- o provide above ground treatment,
- o remove or isolate the source of contamination,
- o discharge treated water to surface water bodies with appropriate permits, or
- o abandon the source of supply.

In-ground treatment was generally not an option until 2 years ago. Generally, several options are coupled in order to achieve the desired cleanup results. Groundwater pump-and-treat systems extract groundwater from underground water supplies and remove contaminants from the water by chemical or physical treatment of the water. Treated water is returned to the ground, processed through a wastewater treatment facility, or depending upon the resulting water quality and regulator and public acceptance, it may serve as a water source for human consumption. See Appendix E for definitions of environmental cleanup terms.

Technical Concerns. The effectiveness of pump-and-treat systems depends directly on site conditions and contaminant chemistry. As the complexity of the contaminated site increases, the likelihood that the pump-and-treat system will effect a cleanup that meets drinking-water standards decreases. Much of the regulatory guidance for groundwater cleanup was written before 1989, when the limitations of pump-and-treat systems were not fully appreciated. Therefore, existing regulatory requirements for groundwater cleanup do not account for limitations inherent in pump-and-treat technology.

Cleanup of groundwater remains one of the most vexing problems to DoD. Chlorinated solvents are particularly difficult to clean up; specifically those categorized as dense non-aqueous phase liquids (DNAPLs) such as trichloroethylene which is used for cleaning equipment at many military installations. Organic liquids are composed of one or more contaminants that do not easily dissolve with water and are denser than water. However, enough chlorinated solvents dissolve in water to cause problems. The Department of the

Army points out that the existence of DNAPLs is recognized by the Environmental Protection Agency as a prime rationale for approving a technical impracticability waiver from existing regulations.

Once a DNAPL contaminates groundwater, the movement of the water under ground spreads the contamination into a plume which radiates outward from the source of contamination and migrates, for the most part, in the direction of water movement. Containing this plume and preventing its migration is the sole purpose of some pump-and-treat systems. In addition to basic plume containment however, some systems are designed to clean up the groundwater. The National Research Council Committee on Groundwater Cleanup Alternatives states that conventional pump-and-treat systems will seldom be able to restore contaminated groundwater to drinking water standards. Groundwater scientists and engineers generally agree that complete aquifer restoration is an unrealistic goal for many, if not most, contaminated sites.

Theoretical cleanup times range from years to centuries or more, depending on the contaminant and geologic characteristics. Furthermore, the scientific community has not agreed on the best methods for estimating cleanup times under complex geologic and chemical conditions. The National Research Council found that many sites requiring groundwater cleanup, will remain contaminated above drinking water standards for the foreseeable future even if the best available technologies are used. Further, the National Research Council points out that an important consideration in evaluating the effectiveness of pump-and-treat systems is not only the level of decontamination they can accomplish but also how long an acceptable level of decontamination will take.

Evaluation Objective

The objective of this evaluation was to determine the cost and effectiveness of DoD groundwater pump-and-treat remediation efforts. Specifically, we focused on sites where groundwater is contaminated with chlorinated solvents. Although a review of the management control program was an originally announced objective, we determined that it would not be useful to review that aspect beyond ascertaining that the DoD components have not been reporting material control weaknesses related to these systems. See Appendix A for a discussion of the scope and methodology. See Appendix B for a summary of prior coverage related to the specific evaluation objective.

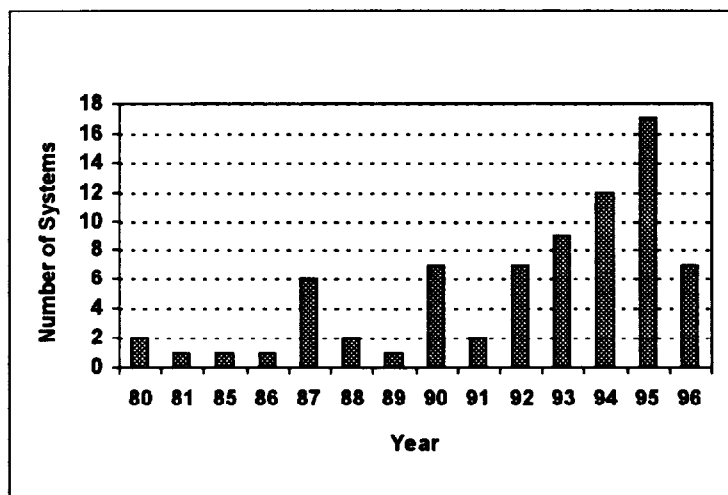
Long Term Operations of DoD Pump-and-Treat Systems

DoD maintained at least 75 groundwater pump-and-treat systems to remedy contaminated groundwater despite the recent development of alternative methods which might remediate contaminated groundwater more effectively. Alternatives to these systems and more effective remediation strategies for other sites are being developed. However, because of the lack of DoD emphasis, in the past, on the remediation related portion of the Defense Environmental Restoration Program, pump-and-treat systems remain in place without adequate analysis of efficiency and effectiveness. Consequently, DoD organizations initially did not develop procedures to determine the most effective means to remediate contaminated groundwater because pump-and-treat systems were the only means available and acceptable to the public and regulators at the time of implementation. As a result, DoD had costly, maintenance-intensive systems that may not be the most effective means to restore the environment; and in the face of a dwindling DERA budget, the costs for environmental clean up could continue to rise. Awareness of the need to seek alternatives is growing, however.

DoD Pump-and-Treat Systems

Number of Systems. DoD installed 78 pump-and-treat systems (75 are in operation today) at sites where the groundwater is contaminated by chlorinated solvents. Of the 75 systems, 38 are for containment only and 37 are for containment and treatment. Figure 1 shows the number of systems becoming operational each year and the time frames in which decisions were made to use pump-and-treat systems. Figure 1 shows that the number of pump-and-treat systems put into operation in 1996 is noticeably lower than in 1995; however, our survey did not identify the reason. Based on responses to our questionnaire, we expect that most of those systems will continue to operate for many years into the future. The costs of continuing to operate pump-and-treat systems have increased on an annual basis reaching \$40 million in FY 1996. Projected cumulative costs are estimated at \$1 billion in the year 2020 for the 75 systems that are operational today. Additionally, DoD has identified 97 new sites where the groundwater is contaminated with chlorinated solvents. Using the average annual cost to operate a pump-and-treat system in 1996, the total costs to operate 97 additional pump-and-treat systems would be \$57 million each year. Projected out to the year 2020, the cumulative cost would be an additional \$1.4 billion. This projected cost does not take into consideration the possibility that some of the 97 new sites may be remediated through natural attenuation and well head treatment as alternative remedies.

Long Term Operations of DoD Pump-and-Treat Systems



**Figure 1: Number Of Pump-And-Treat Systems
Becoming Operational By Year (75 of 78)**

Three of the 78 systems are not in operation today. Two have been turned off and one is in a “standby” mode. Responses to the questionnaire indicate that two of the three systems had no agreed-upon cleanup standard with the regulators and therefore were shut off after a relatively short operational period. The other pump-and-treat system was constructed, tested, and immediately placed in a standby mode. According to the responses to our questionnaire, the decision to install those pump-and-treat systems was premature and based on political pressure to get a treatment system in place. The wisdom of installing pump-and-treat systems at those sites appears questionable.

Open-Ended Operations. Many of the current DoD pump-and-treat systems are operating at sites where the groundwater is contaminated by chlorinated solvents which require long-term operations to remedy. Of the 75 active systems, 48 are interim cleanup actions with no official decision on what the final remedy will be. According to the Department of the Army Corps of Engineers, in many cases interim cleanup actions are put in place in response to political pressure and are not designed to remediate the aquifer. In addition, it has not been determined what DoD will do if it becomes obvious that those systems will not meet their cleanup goals in a reasonable time. In other words, these systems will continue to operate until the regulatory community agrees upon an acceptable final cleanup solution or the system is re-evaluated and an alternative remedy selected. Only 11 of the 75 systems evaluated have an estimated closure date, thus the remaining 64 are open-ended in terms of operational status, that is, operating indefinitely.

In the past, the cost of the open-ended pump-and-treat operations has not been a significant problem because the DoD environmental cleanup program has been provided sufficient funds to meet legislative and regulatory requirements. However, the cost becomes increasingly critical in light of the constrained and decreasing Defense budget; and Congress and the public are highly critical of the slow pace and high cost of Federal cleanup programs.

DoD Pump-and-Treat System Effectiveness

Effectiveness. Groundwater engineers and scientists generally agree that complete restoration of a contaminated aquifer is an unrealistic goal. The limitations and inefficiencies inherent in pump-and-treat technology arise from the difficulties of effectively removing the contaminants absorbed to the aquifer material (silt, sand, and other geologic material); not in extracting groundwater from the ground. As a result of those limitations, other technologies have been developed or are under development and hold promise for the effective cleanup of contaminated groundwater soils in the future. Most pump-and-treat systems were installed before new technologies became available within the last two to three years.

Current Technology. The most widely used and accepted technology for the cleanup of groundwater contaminated with chlorinated solvents is pump-and-treat. While other technologies show promise in the groundwater cleanup arena, a variety of barriers have discouraged those involved in groundwater cleanup from assuming the risks associated with using new technologies that lack a proven track record. Because of the difficulties arising from most pump-and-treat systems, technology applicators such as the Department of the Air Force Human Systems Detachment at Armstrong Laboratory and Technology Laboratories at the Air Force Center for Environmental Excellence have begun looking into other methods of treatment of contaminants at existing sites.

Our analysis corroborates the difficulties of timely remediation of contaminated groundwater. Thirty-six DoD systems are expected to operate, on average, for 29 years. Furthermore, our data indicates variations in the contaminant concentrations of the pumped water at the 75 DoD sites where pump-and-treat systems were operating:

- o 9 percent are increasing,
- o 47 percent are decreasing, and
- o 31 percent have established a state of equilibrium and are not changing.

Future Requirements. DoD has identified 97 additional sites where the groundwater is contaminated by chlorinated solvents. These will require cleanup actions. The most effective technology for cleanup of future sites is not yet known, but the data provided to our questionnaire clearly shows the great expense related to traditional groundwater pump-and-treat systems.

If DoD chooses pump-and-treat systems as a method of cleanup, the future continuing operations costs could be astronomical. Using the average annual cost to operate a pump-and-treat system in 1996, the cost for those 97 future systems would be \$57 million each year. Projected out to the year 2020, the cumulative cost would be \$1.4 billion. However, that extent of continued reliance on pump-and-treat is unlikely.

Emerging Technology. With approval by regulators and acceptance by the community, there are significant new technologies that may prove quite successful in the cleanup of chlorinated solvents in groundwater. The Deputy Under Secretary of Defense (Environmental Security) and the Department of the Army state that natural attenuation is their preferred remedy for groundwater contamination when feasible. Most are still in the study or demonstration phase and are not likely to be proven technologies for another 10 to 20 years. Those technologies (defined in Appendix E) which seem the most promising are:

- o intrinsic bioremediation,
- o air sparging,
- o reactive barriers (walls), and
- o phytoremediation.

Other technologies may also be as promising but are only in the initial stages of development. With regard to those new and developing technologies, it appears that regulators are beginning to consider, and in some cases accept, alternatives to the traditional pump-and-treat technology.

DoD Pump-and-Treat System Efficiency

The potential cost of remediating groundwater on Defense facilities is unknown. The DoD is unable to estimate the total number of contaminated groundwater sites that must be treated and continues to find new sites each year as well as discovering that some existing sites are more contaminated than originally thought.

Present. Based on the data received from the questionnaire for this evaluation, the average annual continuing operations costs (energy, manpower, repairs, sampling, analyses, monitoring and new monitoring wells, etc.) at DoD sites where the groundwater is contaminated by chlorinated solvents averaged \$583,685 per system in 1996 (an increase of 27 percent since 1986 - does not differentiate between inflation and actual cost increase). Table 1 shows this data and includes the predicted annual average cost for a system projected out to the year 2020. From that data, we predict the average annual costs to operate, maintain, and monitor one system will increase to \$742,000 by the year 2000, \$1 million by the year 2010, and will further escalate to \$1.3 million by the year 2020.

Table 1: Average Annual Cost, Actual Cost Through The Year 1996, and Predicted Cost Through The Year 2020*					
Year	Average Annual Cost	Predicted Average Annual O&M Cost	Year	Average Annual Cost	Predicted Average Annual O&M Cost
1981	\$201,600	-	2001	-	\$ 770,604
1982	3,000	-	2002	-	799,597
1983	326,500	-	2003	-	828,590
1984	262,667	-	2004	-	857,582
1985	459,000	-	2005	-	886,575
1986	460,650	-	2006	-	915,568
1987	285,429	-	2007	-	944,560
1988	357,944	-	2008	-	973,553
1989	413,950	-	2009	-	1,002,546
1990	483,134	-	2010	-	1,031,538
1991	522,476	-	2011	-	1,060,531
1992	523,010	-	2012	-	1,089,524
1993	440,247	-	2013	-	1,118,516
1994	546,138	-	2014	-	1,147,509
1995	661,706	-	2015	-	1,176,502
1996	583,685	-	2016	-	1,205,494
1997	-	\$654,634	2017	-	1,234,487
1998	-	683,626	2018	-	1,263,480
1999	-	712,619	2019	-	1,292,472
2000	-	741,612	2020	-	1,321,465

*Average annual costs include the total annual continuing operations cost, plus the total annual monitoring cost for the pump-and-treat systems included in the evaluation.

Long Term Operations of DoD Pump-and-Treat Systems

Figure 2 demonstrates the increasing cost to operate pump-and-treat systems at sites where the groundwater is contaminated by chlorinated solvents. From this figure it is easy to see the annual increasing costs associated with open-ended systems; however, the annual costs may decrease or remain constant depending upon the number of new pump-and-treat systems for that year.

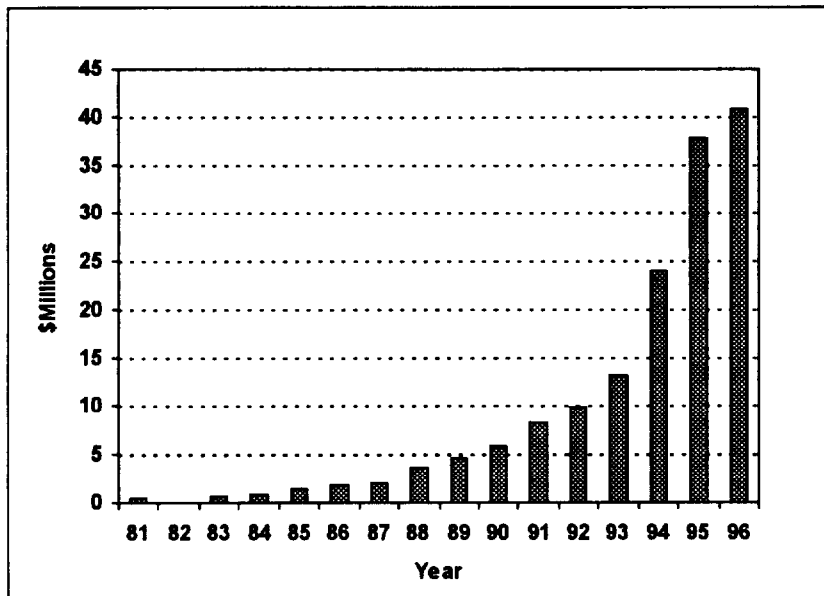


Figure 2: Total Annual Operations and Maintenance Plus Monitoring Costs

Future. Figure 3 shows the estimated operational life of each DoD pump-and-treat system. Each system has an end point in this figure showing the year in which it became operational and an end point that indicates its estimated operational life. The data exhibited is probably conservative because many pump-and-treat system designers selected 30 years as their estimated operational life. That is the maximum number of years that is projected for funding during the feasibility study and may not reflect the actual number of years that the system would have to operate to attain its goals. Project life could also be less if the maximum contaminant level increases or natural attenuation proceeds more rapidly than expected.

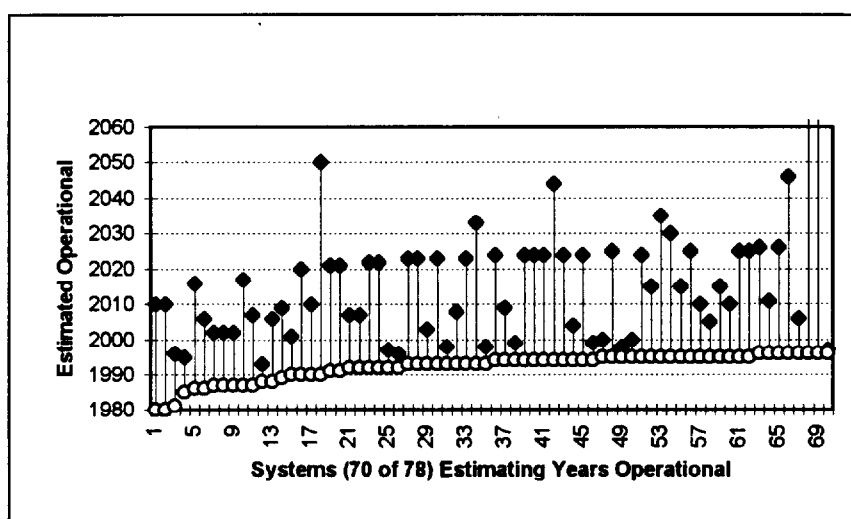


Figure 3: The Year Each System Became Operational Versus The Estimated Operation Life Of The System

Further analysis of the data in Figure 3 indicates that 36 of 70 (51 percent) pump-and-treat systems will still be operational after the year 2010, 29 of 70 (41 percent) will still be operational at the year 2020, and 7 of 70 (10 percent) will remain operational after the year 2030. It should be noted that some of those 70 systems may have to operate longer than estimated to meet required cleanup goals. Similarly, it is important to note that this analysis only includes those systems currently operating and does not include any of the planned future systems.

Using Table 1 and Figure 3 above, we project the cumulative operational costs to be in the range of \$45 million in 1997, \$650 million in 2010, and \$1 billion in 2020. Again this projection is only for those systems currently in operation and does not take into consideration any new future systems or cost avoidance realized by the shut down of interim systems prior to the end of their estimated operational life.

Summary

There is growing recognition that traditional pump-and-treat systems may not be the best solution at all DoD groundwater remediation sites. This is not to say traditional pump-and-treat systems cannot clean up contaminated groundwater; however, the effectiveness of those systems depends strongly upon the properties of the contaminant and hydrogeologic properties of the site. Pump-and-treat systems are good for restoring relatively simple sites; for example, those sites where the geology is fairly uniform and nonstratified. Pump-and-treat systems work well to contain plumes but are very costly to operate and

maintain. Our evaluation determined that a pump-and-treat system remediates an aquifer contaminated with chlorinated solvents very slowly. There may be other, more cost-effective options than operating a pump-and-treat system for extremely long periods of time. Each contaminated site is different and the decision to install a pump-and-treat system must be based on the extent of contamination, site specific characteristics, public stewardship, input from the public and regulatory agencies, and assessment of risk (threat to human health and the environment). Because of regulator emphasis on containing all water contaminated above the maximum contaminant level or reducing all concentrations to below the maximum contaminant level, risk has played a rather insignificant role. From the analysis of the data we gathered on the continuing operation costs of pump-and-treat systems, it is clear that the costs are rising while the DERA funding is decreasing. In this era of decreasing budgets, criticism from Congress and the public, DoD should consider implementing a more aggressive program toward cleaning up contaminated groundwater sites more efficiently and effectively (better, faster, and cheaper).

Additionally, the public and the regulatory community are strongly voicing concerns that a conventional pump-and-treat system may not be able to clean up some types of groundwater contamination. The time and money required to clean up groundwater vary greatly according to the cleanup standards that are set and the current pump-and-treat technology. Since virtually all DoD cleanup work has yet to be done, the prospects for savings in the long term lie in developing less expensive methods of cleanup. Within the constrained budget climate, DoD should not expend valuable resources on pump-and-treat systems for contaminated sites which pose minimal risk. DoD should, in close coordination with the regulatory community, actively explore less expensive methods of cleanup for those sites that are contaminated but do not pose an immediate or short term risk to human health and the environment.

Recommendations, Management Comments, and Evaluation Response

Revised Recommendation. As a result of management comments, we revised Recommendation 1. to clarify the actions for consideration when reevaluating existing pump-and-treat systems.

We recommend that the Deputy Under Secretary of Defense (Environmental Security), the Department of the Army, the Department of the Navy, the Department of the Air Force, and the Defense Logistics Agency:

- 1. Reevaluate the rationale to use pump-and-treat systems at existing sites to determine whether and how pumping can be changed to reduce costs or improve performance and whether pump-and-treat systems should be replaced by alternative technology.**

2. Develop a systematic approach in cooperation with environmental regulators, the scientific community, and the public to determine alternative, more effective methods for future groundwater clean ups.

Deputy Under Secretary of Defense (Environmental Security) Comments. The Deputy Under Secretary of Defense (Environmental Security) concurred with our recommendations and is planning to ask the Tri-Service Environmental Working Group to develop uniform procedures to determine if pump-and-treat systems that can be modified to reduce costs, improve performance, or be replaced by alternative technology. Both the Deputy Under Secretary and the Military Departments indicated they had realized the limitations of the pump-and-treat approach and were working to find alternatives. The Deputy Under Secretary stated that the DoD was much less inclined to install pump-and-treat systems now than in the past.

Army Assistant Chief of Staff for Installation Management Comments. The Army concurred with our recommendations and is actively working to initiate the recommendations. The Army specifically referred to ongoing cooperation with the other Services, EPA, and the scientific community.

Navy Comments. The Navy concurred and has conducted a review regarding Recommendation 1., and has plans to complete Recommendation 2. in 1998.

Air Force Comments. The Air Force concurred with our recommendations and suggested that Recommendation 1. should specifically include cost reduction, performance improvement, and alternative technology.

Defense Logistics Agency Comments. The Defense Logistics Agency partially concurred with the recommendations and provided examples to indicate their methods of current compliance.

Army Corps of Engineers Comments. Although not required to comment, the Army Corps of Engineers suggested that we revise the recommendation to include cost savings and optimizing existing pump-and-treat system performance.

Evaluation Response. Comments by the Army, the Navy, and the Air Force were responsive. Many of those comments were incorporated into this report; however, some comments were outside the scope of this project and consequently were not discussed in this section in the report. The suggestion by the Army Corps of Engineers and the Air Force to include costs, performance, and innovative technology in the recommendation was incorporated into Recommendation 1. Because all addressees were responsive, no further comments are required.

Part II - Additional Information

Appendix A. Evaluation Process

Scope

This evaluation focuses on quantifying the magnitude of financial and technical problems associated with DoD groundwater pump-and-treat systems. The scope of the evaluation included all previous and currently operating DoD sites contaminated with chlorinated solvents.

Methodology

To accomplish the evaluation objectives, we developed detailed questions and requested all DoD installations complete a questionnaire for each pump-and-treat system. The universe was all DoD installations where the groundwater is contaminated with chlorinated solvents and that utilized a pump-and-treat system as the selected remedy. The Military Departments and the Defense Logistics Agency initially reviewed a copy of the draft questionnaire and made suggestions to improve the questionnaire. After the suggested changes were made to the questionnaire by the IG, DoD; final distribution copies were sent to the Military Departments, Defense Logistics Agency, and the U.S. Army Corps of Engineers for distribution to their field installations. No computer-processed data were used in the course of this evaluation. The data we obtained were current as of September 1996.

Use of Technical Assistance. Technical assistance was provided during this evaluation by members of the Quantitative Methods Division of the OAIG-AUD. Assistance provided was in the form of statistically projecting cost data using the method of linear least squares regression.

Evaluation Type, Dates, and Standards. We performed this economy and efficiency evaluation from July 1996 through April 1997 in accordance with standards issued by the Inspector General, DoD.

Contacts During the Evaluation. We visited or contacted individuals and organizations within DoD, the Environmental Protection Agency, and the Department of Energy. Further details are available on request.

Management Control Program

DoD Directive 5010.38, "Management Control Program," August 26, 1996, requires DoD organizations to implement a comprehensive system of management controls that provides reasonable assurance that programs are operating as intended and to evaluate the adequacy of the controls.

Scope of Review of Management Controls. We did not review the Management Control Program beyond ascertaining that the DoD Components have not reported any material control weaknesses related to pump-and-treat systems. This evaluation disclosed no material control weaknesses.

Appendix B. Summary of Prior Coverage

General Accounting Office

Report No. NSIAD-94-133, "Environmental Cleanup: Too Many High Priority Sites Impede DoD's Program," April 21, 1994. The report concludes that too much of DoD's environmental cleanup program was devoted to studying the problem rather than cleaning up installations. Natural cleanup of highly contaminated drinking water aquifers could take hundreds of years because cleaning up aquifers is a relatively new field and efforts to speed up the process have been expensive and have achieved limited success. Groundwater experts believe it is necessary to isolate the contamination source and then by using various methods, including natural cleanup and pump-and-treat systems, confine the spread of the pollution and cleanup the groundwater. There were no recommendations for this report.

Inspector General, DoD

Program Evaluation, "A Study Comparing Department of Defense and Environmental Protection Agency/Private Sector Environmental Cleanups," January, 1995. The results of this limited study conclude that DoD cleanups may be conducted in a manner very similar to the EPA cleanups. In some cases the DoD cleanup sites were cheaper, better and faster in terms of site cleanup. The Inspector General, DoD study suggested that DoD consider investigating various approaches to reduce site characterization time and costs and expedite completion of Records of Decision. Use of low-cost well construction materials could reduce costs and expedite completion of site characterization studies. The study also suggested that the DoD establish an installation-level technical information exchange network to assist its remedial project managers in keeping abreast of the various innovative DoD cleanup approaches used in their local geographic areas. This study did not include formal recommendations and the DoD did not respond.

Appendix C. Questionnaire Data Analysis

The results of the Inspector General, DoD questionnaire indicated that 75 of 78 groundwater pump-and-treat systems (3 are not currently operating) are treating chlorinated solvents within the DoD, and of those, 56 are on the National Priority List (NPL). Of the 78 pump-and-treat systems, 37 are designed to contain and clean the contaminated groundwater while 40 are designed to only contain the contaminated groundwater, and 1 was a well head treatment system.

Analysis of the information provided for the 37 systems designed to contain the plume and clean up the contaminated groundwater indicates:

- o average operational life, for 36 responses, is 29 years,
- o construction costs are \$124 million,
- o system modification costs are \$29 million,
- o concentration levels decreased in 22 systems,
- o concentration levels increased in two systems,
- o concentrations levels leveled off in nine systems, and the remaining four systems do not have enough data to quantify.

Analysis of the information provided for the 40 systems designed to only contain the plume indicates:

- o average operational life, based on 33 responses, is 22 years,
- o total construction costs are \$110 million,
- o total system modification costs are \$17 million,
- o concentration levels decreased in 15 systems,
- o concentration levels increased in five systems,
- o concentration levels leveled off in 13 systems, and the remaining 7 systems do not have enough data to quantify.

Systems Operational By Year. Part I, Figure 1 shows the number of systems becoming operational by year. Part I, Figure 3 shows the number of systems and the years they will be operating after start up.

Appendix C. Questionnaire Data Analysis

Continuing Operations Cost. Part I, Figure 2 shows the total annual continuing operations and monitoring costs. These data are also shown in Table 1 with the predicted annual costs for continuing operations and monitoring of one of these systems. Predictions are based on linear least squares analysis of the actual data from 1981 through 1996. To date, construction costs of the systems are over \$235 million, and modification costs over \$46 million.

Appendix D. Environmental Regulations

National Oil and Hazardous Substance Pollution Contingency Plan. The National Oil and Hazardous Substance Pollution Contingency Plan describes how the mandates from Congress specified in the Comprehensive Environmental Response, Compensation, and Liability Act will be carried out in practice. Central to this Plan, is that groundwater cleanup goals should meet chemical-specific “applicable or relevant and appropriate requirements” from other regulations, known as ARARs.

Comprehensive Environmental Response Compensation and Liability Act. The Act governs any site where there is a release or a threat of release of a hazardous substance. Typically, the Environmental Protection Agency uses this Act to order cleanup at closed or abandoned waste sites. The goal setting process for cleaning up groundwater at CERCLA sites is detailed in the National Oil and Hazardous Substance Pollution Contingency Plan.

Resource Conservation and Recovery Act. The Resource Conservation and Recovery Act provides for cradle-to-grave management of hazardous waste. The EPA uses the statute to require groundwater and soil cleanup at operating hazardous waste treatment, storage, and disposal facilities and at closed facilities that once operated under the RCRA program. The primary EPA regulation for implementing groundwater cleanups under RCRA is known as the Corrective Action Rule. The Corrective Action Rule has not been finalized by EPA, but the EPA is nevertheless using it to oversee ongoing work.

Appendix E. Glossary

Air Sparging. The injection of air below the water table to strip volatile contaminants from the saturated zone and to promote contaminant biodegradation.

Chlorinated Solvent. A solvent containing at least one chlorine atom in its chemical structure. Typically, these compounds are used to dissolve substances that do not dissolve easily in water. Because they are used for a wide variety of purposes--from manufacturing, to degreasing, to dry cleaning--chlorinated solvents are common groundwater contaminants.

Containment. Refers to systems that prevent the further spread of contamination. These systems control the groundwater flow direction around the contaminated site by using pumps, injection wells, and cutoff walls placed at strategic locations.

Conventional Pump-and-treat Systems. Systems that extract contaminated groundwater and treat it at the surface.

Denser-Than-Water Nonaqueous-Phase Liquid. An organic liquid that is denser than water and is composed of one or more contaminants that do not mix readily with water. Chlorinated solvents are DNAPLs which are very slightly soluble in water. Most groundwater contaminant plumes resulting from DNAPLs consist of chlorinated solvents dissolved in groundwater (aqueous phase) rather than unmixed, nonaqueous phase of the solvent.

Intrinsic Bioremediation. A type of in-situ bioremediation that uses naturally occurring microorganisms to degrade contaminants without taking any engineering steps to enhance the process.

National Priority List. A list compiled by the EPA of uncontrolled hazardous substance releases in the United States that are priorities for long term remedial evaluation and response.

Natural Attenuation. The reduction of contaminant concentrations in the environment through biological processes (biodegradation, plant and animal uptake), physical phenomena (dispersion, dilution, volatilization, sorption, desorption), and chemical reaction (ion exchange, complexation, abiotic transformation). Natural attenuation is not a no-further-action alternative. Extensive modeling is typically required.

Nonaqueous-Phase Liquid. A liquid solution that does not mix easily with water. Many common groundwater contaminants, including chlorinated solvents and many petroleum products, enter the subsurface in nonaqueous-phase solutions.

National Oil and Hazardous Substances Pollution Contingency Plan. The regulation describing how the mandates from Congress specified in the Comprehensive Environmental Response, Compensation, and Liability Act will be carried out in practice.

National Pollutant Discharge Elimination System. Program which regulates wastewater discharges to surface waters.

Phytoremediation. The general use of plants to remediate contaminated groundwater.

Pump-and-Treat System. Most commonly used type of system for cleaning up contaminated groundwater. Pump-and-treat systems consist of a series of wells used to pump contaminated water to the surface and a surface treatment facility used to clean the extracted groundwater.

Reactive Barriers. Also known as passive barriers or passive treatment walls or trenches. An in-ground trench that is backfilled with reactive media to provide passive treatment of contaminated groundwater passing through the trench.

Risk Assessment. The evaluation of the degree of hazard or risk association with exposure to contamination of an environmental medium or media by chemicals or radioactive waste for a receptor or receptor populations (human or ecological).

Risk Management. The process of deciding whether remedial actions are warranted, or the extent of remedial actions required, in light of the results of a risk assessment.

Wellhead Treatment. Treatment of extracted water to remove chemicals prior to its use as drinking water.

Appendix F. Report Distribution

Office of the Secretary of Defense

Under Secretary of Defense for Acquisition and Technology
Deputy Under Secretary of Defense (Environmental Security)
Director, Defense Logistics Studies Information Exchange
Under Secretary of Defense (Comptroller)
Deputy Chief Financial Officer
Deputy Comptroller (Program/Budget)
Assistant to the Secretary of Defense (Public Affairs)

Department of the Army

Assistant Secretary of the Army (Financial Management and Comptroller)
Assistant Secretary of the Army (Installations, Logistics, and Environment)
Auditor General, Department of the Army

Department of the Navy

Assistant Secretary of the Navy (Financial Management and Comptroller)
Assistant Secretary of the Navy (Installation and Environment)

Department of the Air Force

Assistant Secretary of the Air Force (Financial Management and Comptroller)
Assistant Secretary of the Air Force (Manpower, Reserve Affairs, Installations and Environment)
Deputy Assistant Secretary of the Air Force (Environment, Safety and Occupational Health)

Other Defense Organizations

Director, Defense Contract Audit Agency
Director, Defense Logistics Agency
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Inspector General, Defense Intelligence Agency

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Office of Management and Budget
Technical Information Center, National Security and International Affairs Division,
General Accounting Office

Chairman and ranking minority member of each of the following congressional committees and subcommittees:

Senate Committee on Appropriations
Senate Subcommittee on Defense, Committee on Appropriations
Senate Committee on Armed Services
Senate Committee on Governmental Affairs
House Committee on Appropriations
House Subcommittee on National Security, Committee on Appropriations
House Committee on Government Reform and Oversight
House Subcommittee on Government Management, Information, and Technology,
Committee on Government Reform and Oversight
House Subcommittee on National Security, International Affairs, and Criminal
Justice, Committee on Government Reform and Oversight
House Committee on National Security

Part III - Management Comments

Deputy Under Secretary of Defense (Environmental Security) Comments



ACQUISITION AND
TECHNOLOGY

OFFICE OF THE UNDER SECRETARY OF DEFENSE

3000 DEFENSE PENTAGON
WASHINGTON, DC 20301-3000

17 FEB 1998

MEMORANDUM TO DOD INSPECTOR GENERAL

(ATTN: MR. WILLIAM C. GALLAGHER, EVALUATION PROGRAM
DIRECTOR)

SUBJECT: Comments on Draft Proposed Evaluation Report: "Evaluation of DoD Waste Site
Groundwater Pump-and-Treat Operations"

Thank you for soliciting our comments on your draft report. We concur with the
recommendations of the report and offer the following comment.

We note that in 1996 there were less pump-and-treat systems put in place than during the
previous year. Our technical knowledge has advanced concerning the value of these systems in
terms of effectiveness, timeliness, and cost. We are much less inclined today to choose a pump-
and-treat system than we were 5 or 10 years ago. One alternative, which we fully support, is the
use of natural attenuation for remediation whenever feasible. We plan to ask the Tri-Service
Environmental Working Group to develop uniform procedures to determine how pump-and-treat
systems can be modified to reduce costs, improve performance, or be replaced by alternative
technology.

If you have questions, or if additional information is required, my staff contact is Mr. Vic
Wieszek, available at (703) 697-9789.

Sherri W. Goodman
Deputy Under Secretary of Defense
(Environmental Security)

Environmental Security



Defending Our Future

Department of the Army, Assistant Chief of Staff for Installation Management Comments



REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT
800 ARMY PENTAGON
WASHINGTON DC 20310-0800



14 JAN 1998

DAIM-ED-R

MEMORANDUM THRU *[Signature]* DIRECTOR OF THE ARMY STAFF

DEPUTY ASSISTANT SECRETARY OF
THE ARMY (ENVIRONMENT, SAFETY, AND
OCCUPATIONAL HEALTH), OASA(I,L&E) *[Signature]*

FOR INSPECTOR GENERAL, DEPARTMENT OF DEFENSE (AUDITING)

SUBJECT: Review and Comment of Evaluation Report on Department of Defense
Waste Site Groundwater Pump-and-Treat Operations (Project No. 6CB-0057)

1. Reference memorandum, OASA(I,L&E), 6 Nov 97, SAB. Army comments on the draft evaluation report from the Office of the Inspector General on DOD Waste Site Groundwater Pump-and-Treat Operations are enclosed.
2. OACSIM point of contact for this action is Mr. Jewel Simmons, (703) 693-0679.

Encl

[Signature]
DAVID A. WHALEY
Major General, GS
Assistant Chief of Staff
for Installation Management

Department of the Army, Assistant Chief of Staff for Installation Management Comments

Final Report
Reference

DAIM-ED-R

SUBJECT: Review and Comment of Evaluation Report on Department of Defense Waste Site
Groundwater Pump-and-Treat Operations (Project No. 6CB-0057)

1. General Comment: The DOD IG Evaluation Report on DOD Waste Site Groundwater Pump-and-Treat Operations reached the same conclusions regarding the effectiveness and cost-benefit of pump-and-treat that the Army and other Services came to several years ago. When the Army and other Services became aware of the inefficiency with existing pump-and-treat systems they began developing guidance and policy for the application of natural attenuation to resolve groundwater contamination challenges. Although at times difficult, the Army has made great strides in gaining acceptance of natural attenuation by the regulatory agencies and the public. The most recent successes have been the signing of a natural attenuation Record of Decision (ROD) at Tobyhanna Army Depot (Sep 97) and the signing of a ROD requiring groundwater monitoring and implementation of well-head treatment of municipal wells to address a trichloroethylene plume under Schofield Army Barracks (Feb 97). Both of these installations are on the National Priorities List (NPL) and the acceptance of less than active remediation of the groundwater shows progress in the Army's efforts to avoid costly remedies. The DOD IG Report fails to mention the Army's efforts in promoting the use of natural attenuation.

2. Specific Comments:

a. Page 2, Discussion - The report states that "...DOD invested almost \$15 billion in its environmental restoration program in FY96." This statement should read "... through FY96," not in FY96.

b. Page 2, last paragraph - The report states that there is no requirement to revisit active pump-and-treat systems at DOD sites. However, the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) requires that at least every five years the lead agency (Army, for Army sites) shall conduct a review of final remedies at sites where waste exceeds levels protective of human health and the environment. OIG review of these reports would have assisted in evaluating and determining the effectiveness of the remedy and whether modifications and/or a new technology should be applied.

c. Page 3, 1st full paragraph - Regarding the comment, "by the early 1990s regulators and scientists began questioning the effectiveness of pump-and-treat systems," the Army and other Services/DOD were among those who began questioning the effectiveness, also. The Army's concern of the effectiveness of pump-and-treat led to the development of guidance and policy on implementing natural attenuation as a viable alternative. While recognizing the limitations of pump-and-treat, regulatory agencies were still pushing for installation of pump-and-treat systems to address groundwater restoration to meet the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs), which are considered Applicable or Relevant and Appropriate Requirements (ARARs) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA).

Revised

Revised

**Department of the Army, Assistant Chief of Staff
for Installation Management Comments**

DAIM-ED-R

SUBJECT: Review and Comment of Evaluation Report on Department of Defense Waste Site
Groundwater Pump-and-Treat Operations (Project No. 6CB-0057)

d. Page 3, 2nd full paragraph - The report states that "several options or groups of options are available to remediate contaminated groundwater: (1) provide in-ground treatment/containment, (2) provide above ground treatment, (3) remove or isolate the source of contamination, or (4) abandon the source of supply."

(1) Regarding option one (1), there are currently no proven in-situ technologies for treating chlorinated solvents in groundwater. There are several technologies in development which have potential. The Army has applied some of these in technology demonstrations to further their development and acceptance by the regulatory agencies. The Army would be interested in reviewing the list of available technologies referred to in the report. The Army continually looks for promising technologies to demonstrate in the field. Under the Project Reliance research and development effort, the Air Force is the lead agency for development of technologies to address remediation of groundwater contaminated with solvents and halogenated organics.

(2) Regarding option three (3), the Army has always stressed and implemented the practice of source removal as the key step in reducing groundwater contamination. Any pump-and-treat system installed in the past has been accompanied by source removal to reduce the load on the groundwater system. The Army continues to focus on source removal or containment as a key component of groundwater remedies, including Natural Attenuation. As demonstrated at Tobyhanna Army Depot, use of source removals dramatically increases the rate of natural attenuation by removing the continuing load on the system.

(3) Regarding option four (4), under CERCLA, once a remedy is determined to be required to address excess risk to human health or the environment, the remedial alternatives must be evaluated against nine established criteria. Among the criteria are the two threshold criteria of protection of human health and the environment and compliance with applicable or relevant and appropriate requirements (ARARs). In order for the alternative to be evaluated against the other seven criteria, it must meet these thresholds. The key groundwater ARAR is the Maximum Contaminant Level (MCL) established under the SDWA for the contaminant of concern. The alternative of abandoning the water supply would not comply with the ARAR and as such, under CERCLA, could not be accepted, unless the ARAR is waived. The Army has only limited success in gaining regulatory concurrence in waiving ARARs based on technical impracticability.

e. Page 3, 3rd full paragraph - The report states that "existing regulatory requirements for groundwater cleanup do not account for limitations in pump-and-treat technology." The Army fully agrees with this statement. However, the cleanup program is driven by these outdated requirements over which the Army has no direct control. The Army has made progress in

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Groundwater Pump-and-Treat Operations (Project No. 6CB-0057)

promoting natural attenuation and is gaining regulatory acceptance, but each individual application must repeat the process of demonstrating its applicability.

Revised

f. Page 3, 4th full paragraph - The report's discussion of Dense Non-aqueous Phase Liquids (DNAPLs) is misplaced since the presence of a DNAPL is already recognized by the EPA as a prime rationale for approving a technical impracticability waiver of an ARAR.

g. Page 5, 1st paragraph - As discussed above (paragraph d.1), the Army is continually focusing its effort on cost saving methods to remove underground contaminants. Any cost saving technology or policy identified by the DOD IG as a result of this evaluation will be of great benefit to the Army.

Revised

h. Page 5, 2nd paragraph, "Number of Systems" - The conclusion that DOD will continue to introduce pump-and-treat systems at an increasing rate ignores the recent progress in gaining regulatory acceptance of natural attenuation and well head treatment as alternative remedies. This change in direction began in FY96, the last year of the data presented in Figure 1 and the year of the first decline in the number of new systems since FY96. That drop in new systems is a result of DOD's own re-evaluation of the cost effectiveness of pump-and-treat systems and its promotion of natural attenuation. The Army expects the rate of new systems to decline, and anticipates the use of future pump-and-treat systems mainly for short term "hot spot" mass removal to enhance natural attenuation.

i. Page 6, Open-ended Operations - The report again concludes that DOD has no plans to review the effectiveness of these systems. As stated in paragraph b above, the lead agency for these cleanup actions is required to evaluate the effectiveness of these systems at least every 5 years. The Army intends to use those reviews to look at alternative technologies as they mature and to also evaluate the application of natural attenuation. Technical impracticability of meeting ARARs will also be re-evaluated with the data in hand on the effectiveness or ineffectiveness of the pump-and-treat remedy.

j. Page 7, 3rd paragraph, "Current Technology" - The report again refers to other technologies without being specific. While the Army is involved with several technology demonstrations addressing chlorinated solvent contamination in groundwater which "show promise," they all have limitations. The physical site conditions that limit the removal of solvents from the soil or bedrock matrices of the aquifers also limit the effectiveness of in-situ remedies.

Revised

k. Page 8, 1st paragraph - Again, the report fails to note the current direction of the Army and other services in promoting natural attenuation. The Army requires all feasibility studies to

**Department of the Army, Assistant Chief of Staff
for Installation Management Comments**

DAIM-ED-R

SUBJECT: Review and Comment of Evaluation Report on Department of Defense Waste Site
Groundwater Pump-and-Treat Operations (Project No. 6CB-0057)

evaluate the application of natural attenuation and document rationale in the ROD if it is not selected. The report assumes that pump-and-treat is the "method of choice" for DOD while the work over the past two years clearly shows the opposite.

l. Page 8, 2nd paragraph - The report accurately portrays the status of replacement technologies as "not likely to be proven technologies for another 10 to 20 years" after repeatedly criticizing DOD for not implementing them 5 or 10 years ago.

m. Page 8, 2nd paragraph - Regarding the application of application of phytoremediation, the Army has successfully demonstrated this technology and has applied it to two NPL sites (Milan and Iowa AAP (explosives)). However, there are severe limitations to this technology: (1) limited to treatment of shallow groundwater unless extracted for above-ground treatment, (2) climate limits. The Army promotes the use of phytoremediation where it is feasible.

n. Page 12, 1st full paragraph - Agree with the need to invest in the development of new technologies to replace pump-and-treat systems to save resources in the long term. However, the current limitations on research and development funds do not support that position. The Services are increasingly dependent on private research into these problems and adopting technologies as they become available. The limited R&D funds available to restoration problems are being funneled into demonstrations of privately developed technologies. Although this is a practical use of limited resources, it limits DOD control over the future of technologies that may solve its problems.

3. Responses to Recommendations for Corrective Action.

a. Recommendation: Re-evaluate the rationale to use pump-and-treat systems at existing sites to determine if they are the best method of remediation.

Response: Agree. The Army intends to re-evaluate all long-term remedies as required under the NCP (5-Year Reviews), including existing pump-and-treat systems. These reviews are conducted in coordination with the regulatory agencies and the Public representatives of the Technical Review Committees and/or Restoration Advisory Boards. As part of the 5-Year Review process, issues such as the appropriateness of technical impracticability waivers for ARARs, application of natural attenuation, and application of emerging technologies will be addressed.

b. Recommendation: Develop a systematic approach in cooperation with environmental regulators, the scientific community, and the public to determine alternative, more effective methods for future groundwater cleanup.

**Department of the Army, Assistant Chief of Staff
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DAIM-ED-R

SUBJECT: Review and Comment of Evaluation Report on Department of Defense Waste Site
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Response: Agree. The Army and other Services have been actively searching for alternative cleanup technologies in cooperation with the EPA and the scientific Community.

The Army's technology program is structured to address the needs of the user (Army installations). Development of enhanced alternative and in-situ treatment technologies for solvents and halogenated organics in groundwater is currently among the top five restoration requirements, along with Unexploded Ordnance (UXO) detection and remediation, technologies and in-situ technologies for treating explosives in groundwater, and three other areas of high potential cost avoidance. The other top priority is development of protocols for determining the applicability of natural attenuation, which also directly supports the Army's direction away from pump-and-treat technology.

The Army, through the Army Science Board, has also developed guidance for determining the applicability of natural attenuation to groundwater contaminated with solvents. This guidance was patterned after the Air Force's successful guidance on natural attenuation of petroleum products in groundwater. The Army has coordinated the guidance with the EPA to gain its acceptance and support. The EPA has, in parallel, developed its own policy on "Monitored Natural Attenuation" which will support the application of natural attenuation. The Army has been successful at Sierra Depot and Tobyhanna Army Depot in gaining regulatory approval and community acceptance of natural attenuation. The Army requires all feasibility studies addressing groundwater to include an evaluation of the applicability of natural attenuation. If natural attenuation is not the selected remedy for groundwater contamination, the Army requires documentation of the rationale within the ROD.

The Army Science Board has recently completed a thorough evaluation of Army groundwater treatment systems. The report is in final draft form and will be used by the Army in development of Army guidance for groundwater treatment optimization.

Department of the Army, Corps of Engineers Comments



REPLY TO
ATTENTION OF

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS, OMAHA DISTRICT
HTRW CENTER OF EXPERTISE
12805 WEST CENTER ROAD
OMAHA, NEBRASKA 68144-3886

CENWO-HX-G

9 January 1998

MEMORANDUM FOR Office of Assistant Inspector General for
Auditing, DoD, ATTN: OAIG-AUD (Mr. Michael
Herbaugh), 400 Army Navy Drive (Room 801),
Arlington, VA 22202-2884

SUBJECT: Evaluation Report on DoD Waste Site Ground Water Pump-
and-Treat Operations

1. We are providing comments on the subject report dated 21 October 1997. The U.S. Army Corps of Engineers (USACE), Hazardous, Toxic, and Radioactive Waste Center of Expertise (HTRW CX) appreciates the opportunity to review the report. These comments reflect the opinion of the USACE HTRW CX.

2. General Comments:

a. The HTRW CX recognizes the limitations of pump and treat technology and takes an active role in advocating the use of alternative and innovative technologies where appropriate. In fact, the Army Corps of Engineers has an innovative technology advocacy program in place to assure the consideration of alternative technologies. However, the HTRW CX has concerns that the report's presentation of the strengths and weaknesses of pump and treat may not be adequately balanced.

b. Without further information on the sites included in the study, it is difficult to evaluate the report's conclusions. Note that many pump and treat systems have been installed for containment purposes only, which is usually indicative of an interim corrective action. This often prevents impacts in the short term; however, it results in systems that are not designed for rapid cleanup. The projected life spans and costs for the systems studied may, in fact, be biased toward long operating periods. The USACE HTRW CX is well aware of the limitations to fully remediate sites with pump and treat systems and agrees that even more aggressive pump and treat designs may also take decades or longer to clean the subsurface, if it is even possible.

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SUBJECT: Evaluation Report on DoD Waste Site Ground Water Pump-and-Treat Operations

c. Based on USACE experiences, there are sites where pump and treat is the only realistic economic alternative, particularly where the contamination is widely distributed and very deep. Some sites have ground water contamination spread over nine square miles and others have ground water contamination to depths of 400 feet or more. Costs for applying many innovative technologies to these types of sites could be astronomical.

d. It must be noted that the use of alternative technologies may represent a significantly larger outlay of capital than the present-worth cost of the operations of the pump and treat system. Thus, even though the operating costs for pump and treat are often significant, they may be smaller than the alternatives when compared on a present-worth basis. The innovative technologies also have operation and maintenance costs. The full magnitude and long-term cost of O&M on some of these "young" technologies, such as permeable reaction walls (PRWs), has not been completely determined yet. Some O&M costs, such as monitoring point installation and sampling and analysis, would be incurred regardless of the technology. As a result, the difference in capital costs between pump and treat and other technologies become even more significant in determining the most cost effective alternative. The selected remedy, whatever it may be, must make economic sense.

e. Although a purely objective, technical approach to selecting a cost-effective remediation alternative would seem to be preferred, this may require a shift in thinking on the part of many of the parties involved in these projects. In some cases, for example, the pump and treat technology may have been selected because it represented the most immediately affordable alternative for the customer who had limited funds available that fiscal year. If alternative technologies were to be chosen, the capital costs may have been higher, even though total long-term operating costs may be much lower. This increased demand for "up-front" dollars may result in fewer cleanup starts in a given year if funding levels are fixed. The concept of initiating remediation at fewer sites per year with current funding may be unpalatable to the public and regulatory agencies involved.

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SUBJECT: Evaluation Report on DoD Waste Site Ground Water Pump-and-Treat Operations

f. The USACE HTRW CX is concerned there may eventually be an unwarranted policy promulgated by DoD that prohibits the use of pump and treat as a cleanup technology. Any policy must recognize the limitations of the alternatives to pump and treat and should require the evaluation of the use of pump and treat on economic and technical grounds on a site-by-site basis.

g. The USACE HTRW CX is currently undertaking an initiative to provide evaluations of existing remediation systems, including pump and treat systems. This initiative grew from an HTRW CX concern that the operators of many systems were inadequately considering the achievement of remediation goals. Instead, they were looking only at maintaining the *status quo*. The initiative will be focused on using the technical capabilities and experience of the various USACE districts to provide recommendations to the installations that would reduce costs associated with operating the systems or to replace or supplement the system with appropriate alternative technologies that offer life-cycle cost savings. A list of districts and potential candidate sites is being developed. Ultimately, the HTRW CX may provide guidance and support services to the districts for performing these evaluations.

3. Specific Comments:

a. Executive Summary, first bullet. Some or many of the 75 systems evaluated for this report were not intended to reach clean-up goals. The objective was often only to prevent further migration. This must be addressed in the report. Also note that many of these sites were designed before most of the innovative technologies were available, when pump and treat was the only practical (as well as financial) alternative. Also, what is the design life (cleanup time) of the existing systems? If the design life is 30 years and the system has only been operating 10 years, it follows that the intended cleanup goal would not have been reached. This should not be construed as a failure of the pump and treat system to operate effectively or to meet its cleanup goal. The report should acknowledge that few if any of the systems evaluated have had sufficient operational time to meet their cleanup goals.

Revised

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SUBJECT: Evaluation Report on DoD Waste Site Ground Water Pump-and-Treat Operations

b. Page 2. The "financial concerns" expressed here should results in a focus on adequate control of contractor costs through adequate technical oversight by Government personnel.

Revised

c. Page 2. Exception is taken to the statement "...there is no requirement to revisit active pump-and treat (sic) systems at DoD sites." EPA OSWER Directive 9355.7-02 requires a review every five years of CERCLA/SARA sites. Cleanup programs at many DoD installations are being performed under CERCLA/SARA, therefore making them subject to this review. Also, most if not all pump and treat sites are subjected to quarterly, semi-annual, or annual ground water monitoring to determine effectiveness of the system. Data is being collected. What is lacking is a systematic evaluation of that data (and funding for it), and the authority (through regulatory channels) to discontinue pump and treat systems when cleanup goals are met.

Revised

d. Page 3, second full paragraph. Treated water can also be discharged to surface water bodies with appropriate permits.

Revised

e. Page 3, second full paragraph, item (1). In-ground treatment of ground water was generally not an option until two years ago. This should be noted in the report, especially since most of the existing pump and treat systems were installed before this time frame.

Revised

f. Page 3, fourth full paragraph. TCE is a solvent rather than a hazardous material found in the solvents.

Revised

g. Page 3, fourth full paragraph, last sentence. This sentence states that organic liquids do not mix with water and are denser than water. Many organic liquids, including TCE, are soluble in water. Only when the concentration of the organic liquid exceeds its solubility in water do they not "mix", and only then does the liquid's density become a factor. Pump and treat systems take advantage of the solubility of the organic liquids, and their effectiveness is also related to that solubility. Few if any pump and treat systems have been installed to control or remove pure product or DNAPL from the ground as this paragraph implies. Instead, pump and treat systems are installed to remove the dissolved phase of these

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SUBJECT: Evaluation Report on DoD Waste Site Ground Water Pump-and-Treat Operations

organic liquids. It is this point that makes source removal an integral part of a successful pump and treat system. Without source removal a pump and treat system may never reach full cleanup of an aquifer. This is not a failure of the pump and treat system; it is a failure to implement a well-rounded remedial action plan using complementary technologies.

h. Page 5, first paragraph, first sentence. The report should acknowledge that feasible alternative methods for remediating contaminated ground water did not exist until a few years ago. Therefore, the statement that "alternative methods...might remediate contaminated groundwater more effectively" is misleading. Also, this paragraph (particularly the third sentence) implies that the selection of the remediation method was made in a vacuum, without the involvement of or input from the public and regulatory agencies. Therefore, while pump and treat may not appear to be "the most effective means to restore the environment" at this time, for all practical purposes it was the only means available and acceptable to the public/regulators at the time of implementation.

Revised

i. Page 5, second paragraph. As stated later in the report, 48 of the 75 pump and treat systems are classified as interim remedial measures, or nearly two-thirds of existing systems. By definition, these are not intended for long-term operation. Therefore the assumption that "It is expected that most of those systems will continue to operate for many years into the future" appears to be in error, or at the very least deserving of additional verification. This should be acknowledged in the report.

j. Page 6, Figure 1. The report should note that permeable reaction walls (PRWs) using zero-valent iron were first applied in the 1995-1996 time frame. PRWs are probably the most promising technology for removal of chlorinated solvents such as TCE in shallow ground water. Note that the number of pump and treat systems put into operation in 1996 is significantly lower than in 1995, perhaps an indication of the more widespread acceptance of alternative technologies in the mid-1990's.

Revised

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Revised

k. Page 6, second paragraph. Selection of pump and treat as an interim action usually indicates an acknowledgment that the method is perhaps not the best for cleaning up the site, hence its selection as a temporary measure. The whole purpose of an interim action is to stop migration or reduce potential exposure while a more thorough or effective remedy is investigated or designed. In many cases the interim actions are put in place in response to political pressure, and are not designed to remediate the aquifer. While the wisdom of doing so may be questionable, it is an incontrovertible fact that public involvement and acceptance plays a role in remedy selection. The report fails to acknowledge these realities and should note that the interim action may not have a cleanup goal *per se*; the goal may only be to reduce contaminant migration, not to remediate the aquifer.

Revised

l. Page 7, second full paragraph. The limitations of pump and treat do not arise from the difficulties in removing contaminants from the water, or getting the water out of the ground, but from the very difficult job of getting the contaminant out of some of the soil in the subsurface. The contaminants often "hide" in soils that do not allow water to pass through easily and the contaminants also sorb to some degree onto the soil particles. As a result, the contaminants are released very slowly into the water that is being pumped by the pump and treat system and much more water than originally existed in the contaminated volume must be passed through the soil to get the contaminants out. Combined with the long times required to remove a given contaminated water volume from the subsurface at sites with low permeability soils, this can result in remediation times that are quite long.

m. Page 7, second full paragraph, last sentence. Use of the past tense in this sentence ("As a result of those limitations, ...") illustrates that many pump and treat systems were already in place before new technologies became available. The report should acknowledge the fact that new technologies have become available only within the last two to three years, during which time the number of new pump and treat system installations has decreased dramatically.

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n. Page 7, third full paragraph. The accuracy of the statement that the regulators or public "have been slow to recognize and approve new approaches" needs to be verified. It has been the experience of the HTRW CX that, where the application of the new technology is technically sound and protective of human health, the public and regulators have been open to new technologies. It is where the risks of failure of the new technology appear significant that there may be reluctance on the part of the regulators. Responsible technology screening and design can overcome this hurdle on specific projects.

Revised

o. Page 8, first paragraph on page. This paragraph implies that pump and treat is chosen "automatically" as the remediation method at DoD sites. All sites are subjected to an analysis of available remediation alternatives, and remedy selection is performed in conjunction with the regulators and the public. In some cases ("fast track projects") pump and treat systems are put in place to reduce contaminant migration while a more thorough evaluation of remedial measures is undertaken. This should be acknowledged in the report.

Revised
Page 7

p. Page 8. Suggest you add "air sparging" to the list of promising technologies for certain sites.

Revised

q. Page 8, last paragraph. The report should discuss how much of the 27% increase in operating costs since 1986 is the result of inflation and how much reflects true increases in operation costs.

Revised

r. Page 10, first paragraph, last sentence. The conclusion reached in this sentence does not necessarily follow from the figure below it. The total costs presented in Figure 2 are a function of the total number of systems in operation. Much of the increase in O&M costs after 1994 is the result of 24 additional systems being brought online in 1995 and 1996. Therefore it is misleading to imply that O&M costs will continue to increase at the same rate as that shown in the figure when the number of new pump and treat systems is declining (only 7 systems brought online in 1996 compared to 17 systems in 1995).

Revised

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Revised

s. Page 11, second paragraph. The cost projections discussed in this paragraph should be termed worst-case, as it does not include cost avoidance realized by the shut down of interim systems prior to their "scheduled" termination.

Revised

t. Pages 11 and 12, carryover sentence. This sentence is an over generalization. Sites with chlorinated solvents are not necessarily more difficult to clean up than sites with certain other contaminants, depending on the tendency for the contaminants to sorb onto the soil particles and the solubility of the contaminant. Other contaminants may even be more difficult to remediate, such as polynuclear aromatic hydrocarbons. The difficulties also arise from complex hydrogeology that would make the removal of any contaminant difficult. A better example of a "simple" site would be one where the geology is fairly uniform and non-stratified.

Revised

u. Page 12, first paragraph. The list of factors determining whether to install pump and treat systems should include input from the public and regulatory agencies. The 56 sites in the survey listed on the NPL are required to consider this input in the remediation process and as a part of the five-year reviews.

v. Page 12, second paragraph. It is ironic that the public and regulatory community would voice concerns over the effectiveness of pump and treat systems. In many cases systems have been installed in response to a perceived need to show that something was being done to remediate a site (even though technically it may not have been the wisest thing to do).

Revised

w. Page 12, Recommendations. The recommendations focus only on alternatives to pump and treat, but significant cost savings can be achieved by optimizing the existing systems, as well. The system re-evaluation should also consider optimizing the means of ground water treatment (chemical oxidation versus carbon adsorption, for example) and reducing the cost of monitoring at the site by limiting the number of samples, the chemical analytes, or by innovative monitoring methods. These activities

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often account for the lion's share of the costs for operations and maintenance. The performance of the pump and treat system can be evaluated, by computer modeling, for example, to determine if the total flow or number of extraction wells can be reduced.

4. Please contact Mr. Dave Becker, CENWO-HX-G, 402-697-2655, (e-mail dave.j.becker@usace.army.mil) with any questions.

FOR THE COMMANDER:



MARCIA C. DAVIES, PH.D.
Director, USACE Hazardous,
Toxic and Radioactive Waste
Center of Expertise

Department of the Navy Comments

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DEPARTMENT OF THE NAVY
OFFICE OF THE ASSISTANT SECRETARY
(INSTALLATIONS AND ENVIRONMENT)
1000 NAVY PENTAGON
WASHINGTON, D.C. 20380-1000

JAN 15 1998

MEMORANDUM FOR THE DIRECTOR OF CONTRACT MANAGEMENT DIRECTORATE (OFFICE OF THE DODIG)

Subj: Review of the Draft Evaluation Report on DoD Waste Site Groundwater Pump-and-Treat operations (Project No. 6CB-0057)

As requested by the memorandum of 21 October 1997 from the Office of the DoD Inspector General, we have completed review of Draft Evaluation Report which assessed problems associated with DoD groundwater pump-and-treat systems. We concur with both of the draft recommendations.

With regard to the first recommendation that the services re-evaluate the rationale to continue the use of pump-and-treat at existing sites, we have already conducted our own review of pump-and-treat systems last April to investigate which systems could be targets for optimization. The results have been passed to NAVFACENGCOM for appropriate action.

With regard to the second recommendation that the services develop a systematic approach to determine alternative, more effective methods for future groundwater cleanup, we are currently working on Long-Term Operations/Long-Term Monitoring guidance for the field. We plan to complete this effort in 1998. It is intended to guide our remedial project managers on how to exit from an ineffective technology, replace it with other technologies that are more effective (sparging, natural attenuation, etc.), and define appropriate endpoints.

With regard to page 2 of the Draft Evaluation Report, "Evaluation Background," fourth paragraph, second sentence: "Specifically there is no requirement to revisit active pump and treat systems at DoD Sites," although DoD does not have specific guidance on pump-and-treat systems, the National Contingency Plan (NCP) does require review of all remedial systems no less than every five years after initiation of the selected remedial action (including pump-and-treat) (40 CFR 300.430(f)(4)(ii) and (f)(5)(iii)(C)).

On page 5 of the Draft Evaluation Report, "DoD Pump-and-Treat Systems," in regard to sentence three of the first paragraph, Figure 1 should read "Figure 1 shows the number of systems becoming operational each year." Figure 1 does not demonstrate that few systems are being turned off as currently stated.

Revised

With regard to "DoD Pump-and-Treat Systems Efficiency" on page 8 of the Draft Evaluation Report, we question the inclusion of new monitoring wells as an annual continuing monitoring cost. They are a one-time cost incurred prior to the beginning of the Long-Term Operations/Long-Term Monitoring (LTO/LTM) phase.

Elsie L. Munsell

ELSIE L. MUNSELL
Deputy Assistant Secretary of the Navy
(Environment and Safety)

Department of the Air Force Comments



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS UNITED STATES AIR FORCE
WASHINGTON DC

28 JAN 1998

MEMORANDUM FOR ASSISTANT INSPECTOR GENERAL FOR AUDITING
OFFICE OF THE INSPECTOR GENERAL
DEPARTMENT OF DEFENSE

FROM: HQ USAF/IL
1030 Air Force Pentagon
Washington, DC 20330-1030

SUBJECT: DoD(IG) Draft Evaluation Report on DoD Waste Site Groundwater Pump-and-Treat Operations, 21 Oct 97 (Project No. 6CB-0057)

This is in reply to your memorandum requesting the Air Force to provide comments on the subject report.

We concur with the summations and recommendations of the subject report. Specific management comments are attached.

If you have any questions or concerns with our comments, please contact Mr. R. J. Furlong, AF/ILEV, DSN 227-3581.

A handwritten signature in black ink, reading "William P. Hallin".

WILLIAM P. HALLIN
Lieutenant General, USAF
DCS/Installations & Logistics

Attachment:
Management Comments

cc:
SAF/FMPF

DoD(IG) Draft Evaluation Report on
DoD Waste Site Groundwater Pump-and-Treat Operations
Project No. 6CB-0057

Summary of Recommendations: We recommend the Deputy Under Secretary of Defense (Environmental Security), the Army, the Navy, the Air Force and the Defense Logistics Agency re-evaluate existing pump-and-treat systems to determine if they are the best method of remediation. We also recommend that a systematic approach be developed in cooperation with environmental regulators, the scientific community, and the public to determine more effective alternative methods for future groundwater cleanup.

AF/IL Comments: Concur.

General Comments:

1. We concur with the recommendation to re-evaluate the rationale for the pump-and-treat (P&T) systems at Air Force sites and to determine if this is the best method of remediation. Alternatives to containment P&Ts include reactive wall, slurry wall, sheet piling, natural attenuation and combinations¹. More alternatives to P&T exist for cleanup situations. The Air Force Center for Environmental Excellence (AFCEE) has published a list of alternatives, several of which are officially recommended in lieu of P&T. We will continue to work with the stakeholders (environmental regulators, scientific community and the public) to determine the most effective methods to cleanup the coordinated sites.

2. Criteria to evaluate P&T systems across DoD will be developed in coordination with the Tri-Service Centers Working Group. The criteria will provide the basis to review the existing P&T systems by the installation remedial project managers and the stakeholders.

3. This report addresses an important issue. The proposed reevaluation of existing and potential P&T systems could result in significant cost savings at some sites. Preliminary screening could identify those sites where savings would be most likely. Savings could be increased further by a program that also includes:

•Renegotiation of some existing records of decision (ROD) and enlightened negotiation of future RODs, promotion of use of P&T plume water for public water supply, and improving consideration of a system design's total cleanup lifetime costs even if the driving ROD specifies only containment goals.

¹ The first three alternatives cannot practicably be installed to the same depth as P&T system. Natural attenuation requires regulator acceptance, and requires fate and transport modeling beyond what is normally funded for solvent plumes. Solvent plumes do not biodegrade as easily as fuel plumes, for which natural attenuation is increasingly proposed.

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4. The report should include a copy of the survey questionnaire it mentions and a table summarizing responses. The report summary table should provide data for all of the 75+ evaluated systems. DoD/IG has provided a summary table, as modified by the USAF Human Systems Center Det. 1 (Armstrong Laboratory). The enhanced table only lists one P&T operation.

Detailed comments:

Executive Summary page i, para 1 (Introduction).

1. After the first sentence, the report should indicate the goal of some P&T systems is containment—preventing the plume from crossing beyond or reaching specified locations. At other sites, the goal is cleanup—causing remaining groundwater contaminant concentrations to drop below specified limits by the end of a planning horizon.

DoD/IG should clarify whether its report only addresses cleanup P&Ts or P&Ts designed for both purposes. Report recommendations could differ for each. Some adjustments of pumping rates currently being used to maintain containment might be practical and may result in reduced cost.

As currently written, the Introduction sets the stage for some confusion because remediation, cleanup and containment seem to be used interchangeably. This is a problem because other paragraphs discuss P&T systems as if they are all designed to achieve remediation (and hence cleanup). In reality, some P&T systems were designed to satisfy the regulatory requirement of plume containment. Such containment systems do achieve some cleanup, but since that was not their primary intent, they should not be evaluated and subsequently criticized as ineffective cleanup systems.

2. Executive Summary page i, para 3 (Evaluation Results).

Please differentiate between P&T systems designed for the different goals of containment and cleanup. Again, those designed to satisfy a ROD containment goal should not be criticized for a slow cleanup.

The statement “will not allow DoD to meet required cleanup goals within a reasonable time,” begs the question “what is reasonable?” Survey results show the predicted cleanup date is still in the future for all surveyed systems. One can argue that “reasonable cleanup time” is at least as long as the cleanup time predicted and considered acceptable during system design. Again, the goal of some RODs is merely containment (to protect those down-gradient) rather than cleanup.

P&T is the only practical containment method virtually guaranteed to receive regulator approval for deep contaminant plumes. One way to make the technique more economical is to promote use of the treated water in public water supplies. Appendix A lists examples where that practice has reduced remediation expense, benefited the public and promoted good will.

3. Executive Summary page i, para 4 (first bullet under Evaluation Results).

Again, not all the P&T systems cited in the summary table were designed to achieve cleanup. Please state the number of systems designed for cleanup versus containment.

We question the statement "none of the 75 systems has achieved the intended cleanup goal or is expected to in the near future." AF Plant 3 in Tulsa is the first P&T site listed in the summary table. The summary table shows startup concentrations of 17,000, 16,500, 50 and 10,900 ppb for TCE, DCE, DCA and TCA, respectively. The table (as enhanced by Armstrong Lab) shows current treatment plant influent concentrations of 5, 200, 7 and 5 ppb for TCE, DCE, DCA and TCA, respectively. These concentrations are at or very near the maximum contaminant level (MCL). Unless they have been unchanging or oscillating for a long time, the cleanup goal is nearly achieved.

4. Executive Summary page i, para 6 (third bullet under Evaluation Results).

The statement might be accurate, but the way it is worded implies criticism. It would be more even-handed to recognize that to reasonably predict closure dates requires more "study" money than DoD has been able to spend on cleanups². Historical data or funds are generally inadequate to permit calibrating and validating fate and transport groundwater contaminant models for plume sites. Without model validation, it is difficult to estimate cleanup times. Thus, closure dates are often not predicted. It is difficult to calibrate and validate a flow and transport model for a site if the magnitude and timing of contaminant reaching groundwater is unknown. Also, field-estimated solvent adsorption and degradation rates vary widely and are not known with certainty and calibration/validations cannot be perfect.

In essence, because there is often not a means of accurately predicting future concentrations, closure dates are often not confidently predicted for P&T cleanup systems. Estimated cleanup closure dates are generally based on very simple assumptions. Closure dates are even less frequently predicted for containment systems because such systems rely on hydraulics to prevent the plume from moving beyond a certain area. Because their design does not require fate and transport modeling, future concentrations and closure dates are rarely predicted. Forecasting future concentrations and closure dates is usually considered unnecessary.

5. Executive Summary, page ii, para 2 (Summary of Recommendations).

Recommendations should distinguish between P&T systems designed for containment versus those designed for cleanup. From the current wording, the Services could infer they should evaluate containment systems to see how well they achieve cleanup. This is awkward, since a ROD driving a containment design normally specifies containment rather than cleanup as the goal.

Even containment systems will eventually achieve cleanup if they are pumped long enough. However, unless RODs are renegotiated, many containment P&Ts will pump until the last of the migrating MCL-exceeding groundwater is extracted. It is desirable to periodically reevaluate such systems, considering their performance, applicability of new cleanup technology, and the ROD the system is designed to satisfy. Combining containment with cleanup systems is sometimes cost-effective.

² Appendix B of the DoD/IG report indicates that GAO criticized DoD for attempting to study cleanup problems too thoroughly. Common results of incomplete studies are remediation designs that are less effective than hoped for or more costly than they would be otherwise.

Department of the Air Force Comments

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Revised

6. page 3, para 3, last sentence.

Change "resulting water quality, it may" to "resulting water quality and regulator and public acceptance, it may."

Revised

7. page 3, para 5, last sentence.

Change "do not mix with water" to "do not easily dissolve in water." Add "However, enough TCE does dissolve in water to cause problems." From this and the next paragraph, the reader needs to understand that the vast majority of solvent plumes consist of TCE dissolved in water. Zones of pure TCE "free-product" in aquifers are relatively uncommon.

8. page 3, para 6.

Clarification is needed. The undissolved TCE moves downward due to gravity. Once it reaches a barrier, such as the base of an aquifer, the undissolved (nonaqueous) TCE continues to move 'downhill' along the top of the barrier. Thus, the undissolved (nonaqueous phase) TCE can even move in a different direction than the dissolved TCE. The dissolved TCE plume moves with groundwater in the direction of decreasing water table elevation (or potentiometric head).

9. page 4, para 1.

Good points. Therefore, follow-up evaluation might be desirable to determine whether cleanup has proceeded far enough to permit natural attenuation to do the rest of the job.

10. page 5, para 1.

The wording is unnecessarily critical. Installed P&T systems were often mandated by a record of decision. For containment, there generally has been no better substitute. For cleanup, AFCEE has long promoted alternatives to P&T. P&T has not been a favored approach since alternatives became available. Several years ago, AFCEE/ERT published guidance indicating natural attenuation was the preferred cleanup of fuels and solvents. However, since then AFCEE was required to develop new protocol for chlorinated solvents which will be issued as a revised Environmental Protection Agency publication.

11. pages 7 and 8., DoD Pump-and-Treat System Effectiveness.

Please specify if this refers to P&T for cleanup, containment or both.

Revised

12. page 7, para 2.

Replace "removing the contaminants from the groundwater; not in extracting the water from the ground" with "removing the contaminants adsorbed to the aquifer material (silt, sand and other geologic material); not in extracting contaminated groundwater from the ground."

Revised

13. page 7, para 4, last sentence.

Replace "contaminant concentration levels at the 75" with "contaminant concentrations of the pumped water at the 75."

Revised

14. page 7, para 3.

Replace "researchers" with "technology applicators such as USAF Human System Det. (Armstrong Laboratory) and Technology Laboratories at AFCEE".

15. page 7, para 4, 1st bullet.

The "increasing" concentrations statement might cause undue concern. A footnote should explain that one can expect increasing concentrations if extraction wells are placed

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slightly down gradient of zones of high concentration. In some cases, this is an optimal (least-cost) design.	
16. page 8, para 1. This paragraph is inaccurate. For the Air Force, traditional P&T is definitely not the preferred method. Other techniques are employed.	Revised
17. page 10, para 2, line 4. Replace "The data exhibited is conservative" with "The data exhibited is probably conservative." MCLs could increase and concentrations could decrease more than expected.	Revised
18. page 10, para 2, last sentence, last line. Replace "to attain its cleanup goals" with "to attain its goals." Add another sentence, "Project life could also be less if MCLs increase or natural attenuation proceeds more rapidly than expected."	Revised
19. page 11, para 3 (Summary), first sentence. We agree P&T might not be the best solution at all DoD remediation sites. However, since the survey does not address the alternatives at all, the report should not state "It is clear from the data gathered in our questionnaire." Suggest you delete that phrase and begin the sentence with "Traditional P&T..." Much depends upon the site, a sandy site is more amenable to cleanup than a silty site.	Revised
20. page 12, para 1, line 9. Replace "Risk has played a rather insignificant role" with "Because of regulator emphasis on containing all water contaminated above the MCL or reducing all concentrations to below the MCL, risk has played a rather insignificant role." Add footnote 3 as shown below. ³	Revised
21. page 12, para 2, sentences 4 and 5. We support these sentences.	
22. page 12, para 4 (item 1). Replace existing sentence with "Re-evaluate use of P&T at existing sites to determine: (a) whether and how pumping can be changed to reduce costs or improve performance, and (b) whether P&T should be replaced by an alternative technology."	Revised
23. page 20, definition 4. Add this definition: "An organic liquid that is denser than water and is composed of one or more contaminants that do not mix readily with water. Sample, "Denser-than-Water Nonaqueous-Phase Liquids (DNAPLs)," are chlorinated solvents, which are very slightly soluble in water. Most groundwater contaminant plumes resulting from DNAPLs consist of chlorinated solvents dissolved in groundwater (aqueous phase) rather than unmixed, nonaqueous phase of the solvent."	Revised
³ Sometimes attempting to expedite RODs has caused problems and wasted funds. A classic example is at the Massachusetts Military Reservation (MMR) where an interim ROD was adopted based on a preliminary risk assessment, incomplete plume assessment and a fast-tracking approach. The interim ROD specifies capturing the leading edges of plumes. More complete plume characterization has shown that to be undesirable.	
5	

Appendix A

Examples of Treating VOC-Contaminated Water and Then Discharging it to Municipal Water Lines

(1) After a large VOC-contaminant plume reached a New Brighton, MN water supply well, an innovative solution was adopted. Other wells were installed to help capture the plume. A treatment facility was constructed. The combined flow from all wells was treated and then discharged to the city water distribution system. Now, the Twin Cities Army Ammunition Plant pumps five or six plume capture wells which discharge to the New Brighton, MN, treatment plant.

The plume has TCE concentrations reaching 2,000 ppb. The wells pump water of about 250 ppb TCE. TCE cannot be detected in the treatment plant effluent. Carbon treatment units are arranged so that non-detection quality is always assured, satisfying legal agreements.

As a result, the towns of New Brighton and Fridley have assured high quality water supplies, and New Brighton has a new water treatment facility. The need to build a system to inject the treated water was avoided. (Martin McCleery, 612 633 2301 x 1651, Twin Cities Army Ammunition Plant)

(2) Water from the Los Angeles Water Department New Hollywood Wells is contaminated with TCE and PCE. Treatment by air stripping and granular activated carbon (GAC) reduces contaminant concentrations below MCL. Treated water is released directly into the public water supply lines. (Melanie Milner, City of Los Angeles, 213 367 3182)

(3) Several wells of the City of Riverside, CA are contaminated with TCE. The city blends water from multiple wells before releasing it into public supply lines, without treatment. For example, discharge from Raub Well No. 5 has exceeded the TCE MCL for about a year. However, the water resulting from blending has concentrations not exceeding about 1 ppb of TCE. Furthermore, water from many wells and several pipelines mixes in the city reservoir, causing further dilution. Compliance monitoring is performed at the reservoir. (Babs Makinde, 909 782 5647, City of Riverside)

(4) The City of San Bernardino, CA, is obtaining and planning to obtain significant amounts of public supply water from the New Mark and Muscly TCE plumes. Five wells, each of 2,000 gpm capacity, capture the leading edge of the New Mark Plume. About five 1,500 gpm wells are being installed to capture the leading edge of the Muscly plume. Upon completion, all pumped groundwater will be treated by liquid-phase carbon and discharged directly into water supply lines, thus significantly increasing public water supply. Paired carbon canisters are used in series to achieve non-detection quality and prevent any chance of contamination entering supply lines. (James Dye, City of San Bernardino, 909 384 5391)

(5) The City of Redlands, CA has two well systems where VOC-contaminated water has been treated and discharged directly to public water supply lines. The Rees Wellhead system uses granular activated carbon (GAC) to treat 800 gpm of TCE contaminated water to nondetection before discharging it into public water lines. Until recently, the three wells of the Texas Wellfield extracted 7,500 gpm of groundwater contaminated by TCE, DCE (both VOCs) and DBCP (a pesticide). The pumped water was being treated by GAC and released into public water lines. These wells are not used now because perchlorate contamination has been detected. (Gary Phelps, City of Redlands, 909 798 7698)

Defense Logistics Agency Comments



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IN REPLY
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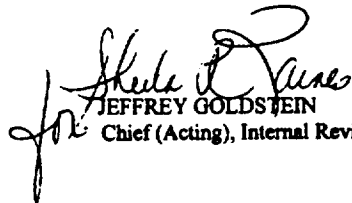
JAN 14 1998

**MEMORANDUM FOR ASSISTANT INSPECTOR GENERAL FOR AUDITING
DEPARTMENT OF DEFENSE**

**SUBJECT: Draft Report: Evaluation of DoD Waste Site Groundwater Pump-and-Treat
Operations (Project No. 6CB-0057)**

This is in response to the October 21, 1997 request. If you have any questions, please contact
Mr. Dave Stumpf, (703) 767-6266.

Encl


JEFFREY GOLDSTEIN
Chief (Acting), Internal Review


Subject: Evaluation of DoD Waste Site Groundwater Pump-and-Treat Operations
(Project No. 6CB-0057)

Finding. Long Term Operations of DoD Pump-and-Treat Systems. DoD maintained at least 75 groundwater pump-and-treat systems to remedy contaminated groundwater despite the existence of alternative methods which might remediate contaminated groundwater more effectively. These systems remained in place without adequate analysis of efficiency and effectiveness because of the lack of DoD emphasis on the remediation related portion of the Defense Environmental Restoration Program. Consequently, DoD organizations did not develop procedures to determine the most effective means to remediate contaminated groundwater. As a result DoD has costly, maintenance-intensive systems that may not be the most effective means to restore the environment; and in the face of a dwindling DERA budget, the costs for environmental clean up could continue to rise.

DLA Comments: PARTIALLY CONCUR. Although I agree with the main thrust of this DOD IG report, the above Finding is not completely accurate. Groundwater pump-and-treat systems normally employ air stripping columns/towers to remove the volatile chlorinated solvents (i.e., remediation). Actually, this was an innovation itself which occurred ~1980 and was promoted by research sponsored by the Air Force. (Air stripping is commonly employed as a chemical engineering process, but prior to ~1980, had not been utilized for groundwater treatment.) It was found to be much more cost-effective than activated carbon adsorption treatment, and became widely implemented throughout DOD in an attempt to remediate these types of sites. However, in the late 1980's, it became apparent that the majority of these pump and treat systems were not able to effectively reduce the levels of these VOC contaminants in the aquifer. (i.e., the air stripping towers very effectively removed the VOCs from the feedwater, but it was simply having little impact on the VOCs remaining in groundwater.) The problem (as alluded to in the DOD IG report) is that these DNAPL VOCs can become trapped in the soil interstices or can actually form free-product pools on top of clay lenses in heterogeneous aquifers, for example. When this happens, the DNAPLs slowly solubilize into the surrounding aquifer, thus making it virtually impossible for a pump and treat process to remove them from the groundwater. Although other technologies/processes are being researched or are undergoing field demonstration, none of them have yet been proven successful for full-scale, widespread implementation. Therefore, it is an unfair criticism to say: "These systems remained in place without adequate analysis of efficiency and effectiveness because of the lack of DoD emphasis on the remediation related portion of the Defense Environmental Restoration Program."

Action Officer: LtCol Robert LaPoe, Ph.D. , DDAI, 767-6255
Review/Approval: Mr. Dennis Lillo, CAAE
Coordination: Mr. Dave Stumpf, DDAI, 767-6266

DLA Approval:


E.R. CHAMBERLAIN
Rear Admiral, SC, USN
Deputy Director

Subject: Evaluation of DoD Waste Site Groundwater Pump-and-Treat Operations
(Project No. 6CB-0057)

Recommendation 1.: We recommend that the Defense Logistics Agency re-evaluate the rationale to use pump-and-treat systems at existing sites to determine if they are the best method of remediation.

DLA Comments: PARTIALLY CONCUR. We are already doing this at DLA. Specific examples of where we have used groundwater cleanup technologies other than pump and treat are:

- A six month treatability test is running at DSCR to evaluate a groundwater dual phase extraction system.
- A groundwater density driven convection system will be pilot tested at DSCR in the near future.
- Groundwater modeling was used at DSCR to show that a BTEX plume would bioremediate before reaching the site boundary.
- A pilot study will be conducted at DDRE to test an in-situ chemical oxidation process in the near future.
- Groundwater modeling is also being used at DDRE to convince regulators that several groundwater plumes will naturally attenuate without impacting the environment.
- Natural attenuation has been accepted for the remediation of a portion of the contamination plume at DDRW-Tracy that extends past Santa Road.
- A dual phase extraction system pilot study was conducted at DDRW-Tracy. However, results indicated that the system would not be cost effective.
- A bench scale analysis was conducted for the use of BTS Humic Polymer for pesticide contaminated soils at DDRW-Tracy. Preliminary results, however, indicate that the technology is inadequate.
- Low Flow pumps have been installed on 15 monitoring wells at DDRW-Sharpe. Early results indicate savings in both time and money.
- Technologies under consideration for groundwater clean-up at DDRW-Tracy and DDRW-Sharpe UST sites include Natural Attenuation and Oxygen Release Compound (ORC). A number of the sites are still being characterized, however. Final recommendations are scheduled for FY '98.
- Phytoremediation using grass is being considered as a potential remedial technology for DDRW-Sharpe UST site 271. This is the location of a surface spill. Motor oil, aldrin, and arsenic have been detected in concentrations exceeding action levels near the surface. The surface consists


of soil and soil/gravel, making this an ideal site for a phytoremediation pilot study. However, the site has not yet been completely characterized. If the contamination is too deep, phytoremediation may not be a suitable alternative.

We have had vendors of innovative technologies and the Corps' AE contractors present briefings to us and our installation personnel. In addition, we have invited installation project managers to attend innovative technology conferences and seminars. Innovative technologies are also discussed during our technical review committee & RAB meetings. The requirement to consider innovative technologies is often included in the Corps' Scope of Work for Recommended Alternatives Studies. Lastly, we are staying abreast of the latest research in this area. (For example, work at the University of Waterloo, at al on reactive barrier walls; EPA/Air Force/Army work on intrinsic bioremediation; Cornell University research in developing a microbe that "eats" these chlorinated solvents; and the Air Force and Army phytoremediation field demonstrations.

Disposition: Action is considered complete.

Action Officer: LtCol Robert LaPoe, Ph.D., CAAE, 767-6255
Review/Approval: Mr Dennis Lillo, CAAE
Coordination: Mr. Dave Stumpf, DDAI, 767-6266

DLA Approval:



E.R. CHAMBERLIN
Rear Admiral, SC, USN
Deputy Director

Defense Logistics Agency Comments

Subject: Evaluation of DoD Waste site Groundwater Pump-and-Treat Operations
(Project No. 6CB-0057)

Recommendation 2: We recommend that the Defense Logistics Agency develop a systematic approach in cooperation with environmental regulators, the scientific community, and the public to determine alternative, more effective methods for future groundwater clean up.

DLA Comments: PARTIALLY CONCUR. See our response to Recommendation 1.

Disposition: Action is considered complete.

Action Officer: LtCol Robert LaPoe, Ph.D., CAAE, 767-6255

Review/Approval: Mr Dennis Lillo, CAAE

Coordination: Mr. Dave Stumpf, DDAI, 767-6266

DLA Approval:



E.R. CHAMBERLIN
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